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Contaminated Sediments in Great Lakes

Areas of Concern

Volume 1: Initial Assessment

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Canada-Ontario Agreement Respecting Great Lakes Water Quality
L'Accord Canada-Ontario relatif à la qualité de l'eau dans les Grand Lacs

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CONTAMINATED SEDIMENTS IN GREAT LAKES
AREAS OF CONCERN

VOLUME 1: INITIAL ASSESSMENT

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for:

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AVANT-PROPOS

Le présent document s'adresse à ceux et celles qui doivent rédiger des rapports intermédiaires sur les plans d'assainissement. Il est l'oeuvre du comité sur les sédiments pollués créé dans le cadre de l'Accord Canada-Ontario relatif à la qualité de l'eau dans les Grands Lacs. Ce comité, qui réunit les représentants des gouvernements fédéral et provincial, s'efforce, en coordonnant les activités de recherche et d'investigation, de parvenir à une meilleure compréhension des effets des sédiments pollués sur l'environnement et à l'établissement des mesures correctrices appropriées.

Le comité facilitera la tâche aux équipes de rédaction tout au long de la mise en oeuvre des plans en préparant divers documents d'ordre général pour les guider et en les consultant individuellement. Le texte que voici est une première étape qui :

- a) explique pourquoi il y a lieu de s'inquiéter des sédiments pollués;
- b) décrit la première phase d'une méthode d'évaluation en deux phases destinée à garantir un minimum de données sur les sédiments dans tous les secteurs de préoccupation; et
- c) expose les activités en cours qui donneront lieu à la formulation, d'ici deux ans, de recommandations supplémentaires détaillées pour la deuxième phase des évaluations.

Ce premier document vise essentiellement à atteindre un certain degré d'uniformité parmi les équipes de rédaction dans la façon dont elles évaluent les sédiments pollués et présentent les mesures correctrices recommandées. La formule qu'il préconise, toutefois, ne doit pas retarder l'application des décisions à l'égard de mesures correctrices précises si une équipe est déjà parvenue à ce stade.

FOREWORD

This document has been prepared by the COA Polluted Sediment Committee to assist RAP writing teams during development of their interim reports. The COA Polluted Sediments Committee is comprised of federal and provincial representatives who are seeking to achieve an enhanced understanding of the environmental impacts of polluted sediments, and appropriate remedial actions, by coordinating research and investigation efforts.

The Committee will be providing continued assistance to writing teams throughout the RAP process through the preparation of general advisory documents, and through direct consultation with individual teams. This document represents a first step which:

- (a) provides a general description of the reasons for concern about polluted sediments;
- (b) describes the first of a two-phase assessment procedure designed to ensure that a minimum range of sediment related data are available at all Areas of Concern; and
- (c) outlines ongoing activities which will, over the next two years, lead to additional, detailed recommendations for secondary phase assessments.

The aim of this first document is to achieve a reasonable degree of standardization among writing teams in their approach to the assessment of polluted sediments and their recommendations for remedial measures. The approach which is advocated is not intended to pre-empt or postpone decisions concerning specific remedial actions where individual writing teams have already reached this stage.

1.0 INTRODUCTION

1.1 Effects of Polluted Sediments

Polluted sediments are a problem in Areas of Concern because of potential impacts related to toxicity, bioaccumulation and biomagnification, and the release of contaminants to the water column. In general, compounds such as heavy metals and trace organics are of the most concern, since it is now generally accepted that sediments are not only a sink, but also a potential source, for contaminants. This has major implications in most Areas of Concern since the response to point source controls (or reductions in tributary loadings) may be considerably slower than that forecast through examination of water quality alone.

The following section describes the potential for problems associated with polluted sediments and outlines an approach to assessment at Areas of Concern.

1.1.1 Toxicity

Toxic effects on benthic organisms may be acute or chronic. In some instances sediments may be rapidly lethal to benthos or bottom-feeding fish, while in others sub-lethal effects (such as chromosomal abnormalities or negative impacts on reproduction) may be significant. Either case may lead to an adverse impact on benthic macroinvertebrate community structure, which may in turn disrupt the species diversity and numbers of predator organisms, ultimately leading to the loss of desirable species at higher trophic levels (e.g. sport fish).

1.1.2 Bioaccumulation and Biomagnification

The uptake of contaminants associated with sediments by benthic organisms may be of concern even if no toxic effects are evident at that trophic level. Although contaminant concentrations in the tissue of benthic macroinvertebrates may be sufficiently low to have no apparent ill effects on the organism, these organisms will represent a source of the contaminant to predator species.

It is possible for contaminant concentrations in the tissue of organisms at higher trophic levels to exceed greatly those found in benthic organisms. This will depend upon such factors as physical and chemical characteristics of the contaminant, the relative rates at which organisms throughout the food web ingest food and eliminate waste, and the relative efficiency with which biota retain contaminants. These contaminant concentrations may lead to acute or sublethal effects on certain aquatic species, as well as having a potentially harmful effect on terrestrial species which consume fish (including humans).

1.1.3 Water Quality

Aquatic organisms will be exposed to contaminants directly via the water column, as well as indirectly via the food web, and consequently, the release of contaminants from sediments to overlying water is of concern even for hydrophobic substances. Contaminant release may result from the physical resuspension of sediments into the water column by wave action, dredging, or shipping. It may also occur as the result of bioturbation or chemical processes which change the chemical bonding between a substance and sediment particles.

Re-introduction of contaminants into the water column may lead to a cycle of toxicity and food web effects which parallels those already discussed for sediments.

1.2 Approaches to Sediment Quality Assessment

Given the range of potential problems associated with contaminated sediments, it is evident that an adequate assessment of sediments in an Area of Concern must include more than chemical analysis of bed sediments. The Polluted Sediment Committee recommends that a two-phase assessment procedure be adopted to evaluate fully the extent and significance of contaminated sediments.

The first phase would be an initial assessment of fundamental sediment related components of the aquatic ecosystem. This will be beneficial in two ways. It will permit a preliminary evaluation of the severity of the polluted sediment situation at an area (possibly identifying the need for immediate remedial action), as well as forming the basis for detailed, second-phase assessment of specific components.

The fundamental components to be examined in the initial assessment are bulk sediment chemistry, benthic enumeration, benthic body burdens, and suspended sediment source characterization. These data should first be assessed for their adequacy, and then interpreted as to their significance. Following this initial assessment it should be possible to identify the need for: (a) immediate action, (b) a detailed assessment, or (c) some combination of the two.

The next chapter outlines general criteria for assessing the adequacy of existing data and then suggests appropriate methods for their interpretation.

2.0 INITIAL ASSESSMENT PROCEDURES

2.1 Adequacy of Data

Evaluation of the adequacy of available data will lead to the identification of gaps and deficiencies preventing completion of a thorough initial assessment. Criteria for evaluation of the four fundamental types of data can be summarized under the headings of spatial variation, temporal variation, sampling methods, and parameters. Table 2.1 depicts the data types and corresponding evaluation criteria.

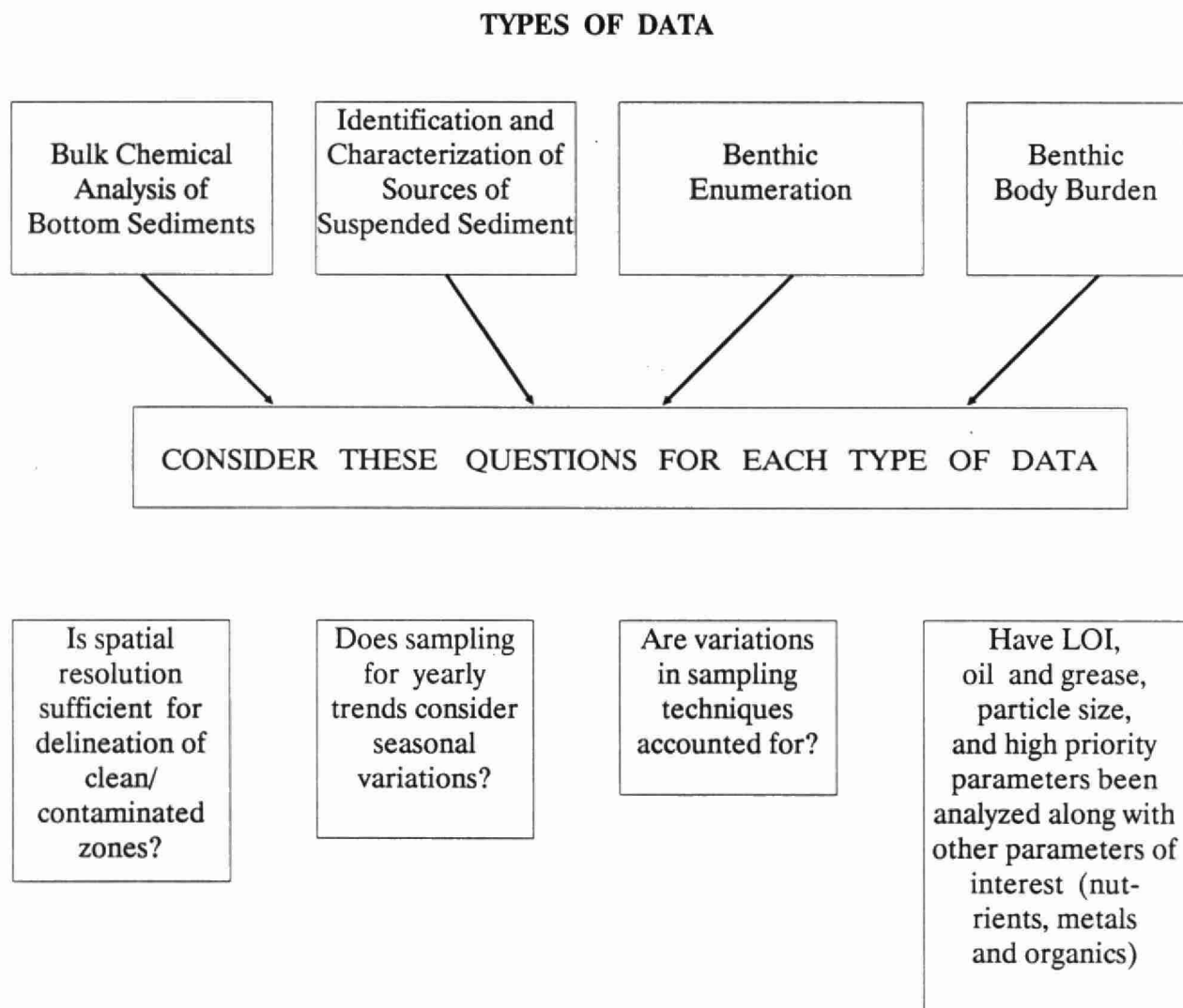
2.1.1 Spatial Variation

Chemical and biological data sets should permit the delineation of spatial variation with sufficient resolution to identify zones of "clean" and "contaminated" sediments. In many cases sediments will be highly heterogeneous and delineation of localized contamination will require numerous sample sites and replicates to permit statistically significant conclusions to be reached. Source characterization may be of assistance in the development of appropriate sampling approaches. A balance between maintaining manageable sample loads and increasing the spatial resolution and statistical confidence of the results will need to be achieved in future investigations. However, it will be to the ultimate advantage of the RAP team to discriminate as finely as possible between contaminated areas, and areas requiring little further attention.

2.1.2 Temporal Variation

The sediment component of the nearshore ecosystem should not be assumed to be static. The distinction between depositional areas, erosional areas, and areas of transport can depend upon the time scale that is chosen due, for example, to seasonal variation in transport energy or sediment supply. Such seasonal differences can lead to variations in sediment type (and hence sediment quality) independently of the changes

TABLE 2.1: EVALUATION CRITERIA OF DATA ADEQUACY



in quality which may also be occurring due to effluent quality fluctuations at sources. Changes in sediment type will also affect the benthos. Seasonal variations are also to be expected in benthic enumeration and body burden studies due to changes in life-stages of the organisms.

This potential for seasonal variation should be considered when attempting year-to-year trend assessment using sediment chemistry, benthic enumeration, or benthic body burden data.

2.1.3 Sampling Methods

Sampling and analysis of sediment, suspended sediment, benthic body burdens, and benthic community structure can be undertaken using various methods which may bias the results. This should be recognized when examining trends in chemical or biological data, since variation in techniques may limit the extent to which trends can be quantified.

If new data are to be collected, decisions about techniques should be made with past practices in mind. If no data exist, or if previous methods are deemed unacceptable or inappropriate, the Polluted Sediment Committee will provide reference material and advice upon request.

2.1.4 Parameters

Parameters selected for sediment chemistry, benthic body burden, or suspended sediment analysis should be guided by existing knowledge of contaminant loadings. In some areas it will be possible to take advantage of recent detailed effluent characterization studies undertaken by MOE as part of the MISA (Municipal Industrial Strategy for Abatement) pilot site or sewage treatment plant investigations. The complete list of parameters will probably include nutrients, metals, and some range of trace organic compounds. In all cases particle size, percentage loss on ignition (%LOI), and solvent extractables (oil and grease) should be analyzed in sediments (since these are often indicative of the presence or absence of other contaminants), as should the high priority parameters PCBs, Hg, Pb, and Cd.

2.2 Data Interpretation

Some degree of data interpretation will be possible, even if gaps and deficiencies have been identified in the available information base. Each of the fundamental types of data can be judged from an environmental viewpoint as "acceptable" or "unacceptable" on its own, although ultimate conclusions will need to reflect their interrelated nature (refer to Figure 2.1).

2.2.1 Sediment Chemistry

The Polluted Sediment Committee is in the process of developing biologically based sediment quality guidelines which will reflect toxicity, bioaccumulation and biomagnification, and water quality effects. Until these guidelines become available (1988/89), bulk chemistry results (i.e. analysis of total sample including all particle size ranges) can be compared with the existing MOE guidelines for open water disposal of dredged material. In general, parameters measured to exceed these guidelines can be identified as being "unacceptable" and of concern, although consultation with the Committee is recommended since this will not always be the case (i.e. there are certain deficiencies associated with the existing guidelines which may result in an over-stringent interpretation). Case-by-case consultation with the Committee will be necessary for parameters which are not included in the dredging guidelines.

2.2.2 Benthic Enumeration

Assessment of benthic macroinvertebrate community structure is recommended as a basic means of identifying the biological impact of contaminated sediments to provide an indication of general health.

Such an assessment examines both species diversity and their relative densities. It assumes that in a "natural" state with a "healthy" benthic community, a balance between the number of invertebrate taxa and the number of organisms within each taxon exists that does not

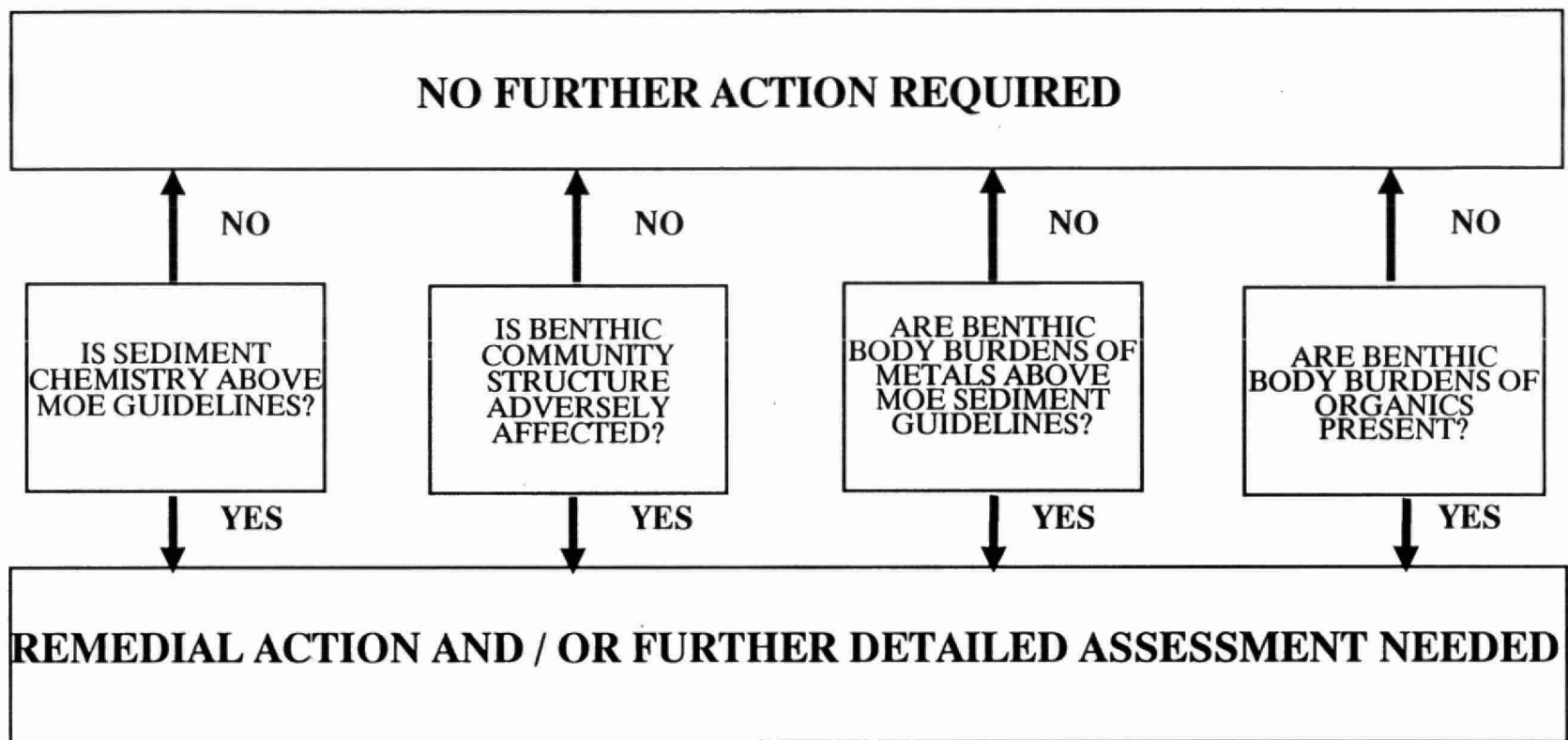


Figure 2.1 Data Interpretation

exist in an artificially stressed or "unnatural" state. Typically, a stressed environment exhibits reduced species diversity due to toxicity on individual organisms and toxic effects on sensitive predator species.

Identification of areas with stressed communities can be achieved through comparison of potentially affected sites with control sites, historical data, or results from a similar body of water. Certain similarities between sites must exist in order to make these comparisons meaningful. Such "habitat" factors as flow characteristics, sediment type (including particle size, organic content, and oil and grease content), and macrophyte composition and abundance must be similar if differences in benthic community structure are to be attributed to contaminated sediments.

The delineation of zones with a stressed benthic community structure does not identify toxicity associated with metals or organics in sediments as the cause. A variety of physically related factors, such as oxygen depletion, or elevated levels of oil and grease, could be responsible. Despite this uncertainty, stressed areas should be designated as being of concern.

2.2.3 Benthic Body Burdens

Tissue analysis of benthic organisms can reveal the presence or absence of contaminants and indicate the potential for transfer from sediments to the benthic food web. Although predator organisms may ingest contaminants found both in the tissue and gut of a benthic macro-invertebrate, it is generally useful to define body burden as the contaminant concentration retained in the tissue only.

Whether tissue concentrations are computed (using correction factors for gut content) or measured directly, the presence of any organic compound not occurring naturally (e.g., pesticides, industrial organics) should be viewed as sufficient reason for concern. For metals (some of which are essential to sustain life) any body burden concentration greater than the MOE dredging guidelines for open water

disposal of dredged material should lead to designation of a concern requiring further study and/or remedial action. The dredging guidelines are to be revised to incorporate biological implications. Body burden data will form part of the basis for development of these new sediment quality guidelines (discussed in Section 2.2.1) which will become available during 1988/89. These new sediment quality guidelines are expected, therefore, to become relevant to interpretation of benthic body burdens. Procedures have been initiated towards developing biota guidelines, at which time these guidelines will be used to access acceptable levels in tissue rather than using sediment guidelines.

2.2.4 Interpretation of Suspended Sediment Data

Unlike sediment chemistry, benthic enumeration, or benthic body burden data, results of suspended sediment sampling at sources will not be interpreted as "acceptable" or "unacceptable". Instead, the chief use of the data will be to rank point sources according to the quality and quantity of their suspended sediment discharges, and to identify the presence or absence of certain contaminants at point sources which have been detected in bed sediments or benthic organisms.

Establishing a link between particulate forms of contaminants which are present at point sources and in either deposited sediments or local benthic organisms will be helpful. Such a link will be needed to make recommendations for specific "source control" remedial actions and to predict their relative effectiveness.

3.0 ONGOING ACTIVITIES

It is probable that at many Areas of Concern completion of an initial assessment will not provide sufficient information upon which to base decisions about potentially costly remedial actions (although it will delineate high priority zones and identify specific information gaps). In these cases further assessment of specific ecosystem components will be necessary to identify the most appropriate and effective course of action.

These detailed assessments are likely to fall under the headings of laboratory bioassessment, sediment transport, and food web assessment. The COA Polluted Sediment Committee is coordinating various federal and provincial investigations related to these subject areas. Some are currently in progress while others are in the planning stage. Findings (which will become available to RAP writing teams over the next two years) will be submitted for inclusion in an "Assessment and Options" document of the IJC Sediment Subcommittee.

3.1 Bioassessment

Detailed bioassessment will go beyond field enumeration and measurement of body burdens, to determine the toxicity and uptake of contaminants by certain test organisms under controlled laboratory conditions.

A contract is to be administered by the COA Polluted Sediments Committee which will recommend a short list of the laboratory bioassessment procedures best suited to the range of conditions found at Areas of Concern. A comprehensive literature review will be completed by early 1988, with an experimental component to be carried out during 1988/89.

3.2 Sediment Transport

Some quantification of transport (including deposition and resuspension) will be necessary to relate particular sources to zones of polluted sediments within an Area of Concern. Such an understanding will help guide the application of controls to the most significant sources, and will allow an estimation of the expected response.

A number of studies are in progress (including those by both MOE and DOE along the Toronto Waterfront) which will lead to specific recommendations for preliminary assessments at Areas of Concern by 1989/90.

3.3 Food Web Assessment

One of the most important reasons that polluted sediments are a problem in Areas of Concern is the potential lag that they may cause between contaminant reductions at point sources, and reductions in concentrations of contaminants in water and in the tissue of aquatic biota such as fish. Until this lag is better understood, it will not be possible to estimate the "recovery" rate at Areas of Concern.

Several contaminant "fate and transport" investigations are in progress at Areas of Concern as part of the MISA pilot site studies. The COA Polluted Sediments Committee will be meeting with staff of involved agencies (MOE, DOE) to discuss the development of sediment/benthic food web components in fate and transport models. Preliminary results will become available during 1988.

4.0 OPTIONS FOR POLLUTED SEDIMENT REMEDIAL ACTIONS

Detailed discussion of options for remedial actions directly associated with contaminants in sediments is beyond the scope of this preliminary document.

Despite this, the Polluted Sediment Committee wishes to stress that in all cases the most important remedial action will be control of sources. Attempting to alleviate "in-place" problems will not be worthwhile unless active sources have been (or are being) reduced. Also, as stated earlier, any RAP team that feels in the position to proceed with recommendations for remedial actions is encouraged to do so. The Committee will assist on a case-by-case basis using the range of information currently available to it.

The Committee will continue to support investigations into alternatives for clean-up of contaminated sediments, and additional details will be provided in future publications. Results will also be provided to the IJC Sediment Subcommittee.

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